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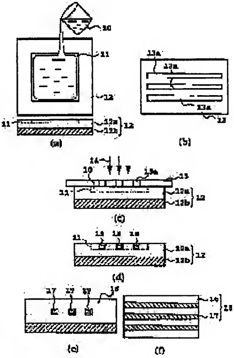
(54) FORMING METHOD OF HIGH POLYMER LIGHT WAVEGUIDE PATTERN FOR APERTURE CONVERTING

(57)Abstract:

PROBLEM TO BE SOLVED: To easily improve mass productivity, and facilitate connection with a light part by forming a pattern latent image by irradiating the light by forming a photosensitive substance in a layer shape in a part where a light waveguide is formed, forming a light waveguide pattern by removing a light unirradiated part by a solvent, and selecting this photosensitive substance from a group composed of a photosensitive oligomer and a photosensitive film.



SOLUTION: A process (a) of forming a photosensitive substance in a layer shape in a part where a light waveguide is formed, a process (c) of forming a pattern latent image by irradiating the light to a prescribed part of the photosensitive substance and a process of removing the other part of a light unirradiated photosensitive substance by a solvent, are provided. A light waveguide pattern is formed by using a pattern latent image unformed part as a core part of the light waveguide. This photosensitive substance is selected from a group composed of a photosensitive oligomer and a photosensitive film. That is, a film is hardened by light

irradiation, and is developed by a proper solvent, and the waveguide pattern having a sharp and smooth wall surface can be formed.

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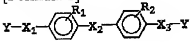
CLAIMS

[Claim(s)]
[Claim 1] A mask is minded [which should form optical waveguide] to the process which forms the photosensitive matter in the shape of a layer, and the predetermined part of this photosensitive matter. Or it has the process which performs an optical exposure directly and forms a pattern latent image, and the process which removes with a solvent other parts of said photosensitive matter with which said optical exposure was not made. It is the approach of forming the optical waveguide pattern which uses as the core part of optical waveguide said predetermined part in which said pattern latent image was furthermore formed. Said photosensitive matter The macromolecule optical waveguide pattern formation approach for aperture conversion characterized by being chosen from the group which consists of photosensitive oligomer and a photographic sensitive film.
[Claim 2] The process with which said photosensitive matter which is an approach according to claim 1, formed the liquid pool in the part which should form said optical waveguide beforehand, and became liquefied at this liquid pool is filled, Form a slot in the both sides of this liquid pool, and an optical fiber is prepared in this slot. And the macromolecule optical waveguide pattern formation approach for aperture conversion characterized by having further the process which performs alignment of said photosensitive matter and said optical fiber arranged in said slot, and said core part and said optical fiber making optical connection.
[Claim 3] The process with which said photosensitive matter which is an approach according to claim 1, formed the liquid pool in the part which should form said optical waveguide beforehand, and became liquefied at this liquid pool is filled, Form a slot in the both sides of this liquid pool, and a microoptics component is prepared in this slot. And the macromolecule optical waveguide pattern formation approach for aperture conversion characterized by having further the process which performs alignment with said microoptics component arranged in said photosensitive matter and said slot, and said core part and said microoptics component making optical connection.
[Claim 4] It is the macromolecule optical waveguide pattern formation approach for aperture conversion characterized by being chosen from the group which it is the approach of indicating to claim 3, and said microoptics component becomes from laser diode (LD), light emitting diode (LED), and light-receiving diode (PD).
[Claim 5] It is the macromolecule optical waveguide pattern formation approach for aperture conversion which is an approach given in claim 1 thru/or any 1 term of 4, and is characterized by said photosensitive matter consisting of photosensitive oligomer and a photopolymerization initiator.
[Claim 6] It is an approach given in claim 1 thru/or any 1 term of 5, and said photosensitive oligomer is a general formula (1).
[Formula 1]

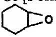


(1)

(Expressing the connection radical which R1 and R2 show a hydrogen atom, a halogen atom, an alkyl

group, an alkoxy group, or a trifluoromethyl radical independently among a formula, respectively, and X1, X2, and X3 contain the alkyl group, the alkyl ether radical, and the ring, and contains the OH radical of a piece at least, Y is [Formula 2].)

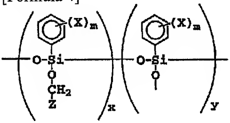
Or [Formula 3]



A ****** active group is shown. The macromolecule optical waveguide pattern formation approach for aperture conversion characterized by being the epoxy system oligomer expressed.

[Claim 7] It is an approach given in claim 1 thru/or any 1 term of 5, and said photosensitive oligomer is a general formula (2).

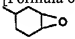
[Formula 4]


(2)

(X expresses a hydrogen atom, a heavy hydrogen atom, a halogen atom, an alkyl group, and an alkoxy group among a formula, and m expresses the integer of 1-4.) Z is the epoxy group and [Formula 5] which are shown in the following type (I) or (II).


(I)

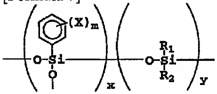
[Formula 6]


(II)

x and y -- the abundance of each unit -- being shown -- y -- x -- small -- 0 -- you may be -- the macromolecule optical waveguide pattern formation approach for aperture conversion characterized by being the liquefied silicone epoxy oligomer expressed.

[Claim 8] It is an approach given in claim 1 thru/or any 1 term of 5, and said photosensitive oligomer is a general formula (3).

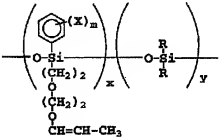
[Formula 7]


(3)

(X expresses a hydrogen atom, a heavy hydrogen atom, a halogen atom, an alkyl group, and an alkoxy group among a formula, and m expresses the integer of 1-4.) x and y show the abundance of each unit and x and y are not 0. R1 and R2 a methyl group, an ethyl group, and an isopropyl group -- expressing -- R1 R2 a phase -- being equal -- the macromolecule optical waveguide pattern formation approach for aperture conversion characterized by being the liquefied silicone oligomer expressed.

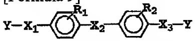
[Claim 9] It is an approach given in claim 1 thru/or any 1 term of 5, and said photosensitive oligomer is a general formula (4).

[Formula 8]



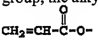
(4)

(X expresses a hydrogen atom, a heavy hydrogen atom, a halogen atom, an alkyl group, and an ARUKOSHIKI radical among a formula, and m expresses the integer of 1-4.) x and y show the abundance of each unit and x and y are not 0. R -- a methyl group, an ethyl group, and an isopropyl group -- expressing -- the macromolecule optical waveguide pattern formation approach for aperture conversion characterized by being the liquefied silicone vinyl ether oligomer expressed.
[Claim 10] It is an approach given in claim 1 thru/or any 1 term of 5, and said photosensitive oligomer is a general formula (5).
[Formula 9]

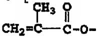


(5)

(R1 and R2 show a hydrogen atom, a halogen atom, an alkyl group, an alkoxy group, or a trifluoromethyl radical independently among a formula, respectively, X1, X2, and X3 contain the alkyl group, the alkyl ether radical, and the ring, they express a connection radical, and Y is [Formula 10].)



Or [Formula 11]



A ****** active group is shown. The macromolecule optical waveguide pattern formation approach for aperture conversion characterized by being the acrylic oligomer expressed.

[Translation done.]

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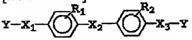
DETAILED DESCRIPTION

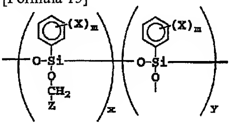
[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the macromolecule optical waveguide pattern formation approach for aperture conversion that it is available to the various optical waveguides and the optical integrated circuit which are used in the general optical field, the microoptics field, the optical-communication field, the optical information field, etc., an optical patchboard, etc., excel especially in mass-production nature about the manufacture approach of optical waveguide using polymeric materials, and connection with optical components is made easily.
[0002]
[Description of the Prior Art] From the former, the thin film formation by the spin coat method, a dip method, etc. is easy for polymeric materials, and it is known that it is suitable for producing the optical waveguide of a large area. Moreover, since the manufacture approach of optical waveguide using such polymeric materials does not include the heat treatment process in an elevated temperature on the occasion of membrane formation, it has the advantage that heat treatment in an elevated temperature can produce optical waveguide for a semi-conductor substrate, a plastic plate, etc. on a difficult substrate, compared with the case where inorganic glass ingredients, such as a quartz, are used. Furthermore, production of the flexible optical waveguide which harnessed the property which a giant molecule has, for example, flexibility, and toughness is also possible. Manufacturing in large quantities and cheaply optical waveguide components, such as an optical integrated circuit used in the field of optical communication and an optical patchboard used in the field of optical information processing, from such a thing using a macromolecule optical material is expected.
[0003] Conventionally, it has been supposed that there is a problem a macromolecule optical material in respect of resistance tos environment, such as thermal resistance or moisture resistance. However, the ingredient which raised thermal resistance is reported by including aromatic series radicals, such as the benzene ring, in recent years or by using an inorganic polymer (for example, JP,3-43423,A). Moreover, polymeric materials have the description in thin film formation, a heat treatment process, etc. as mentioned above, and thermal resistance, moisture resistance, and the trouble that was are also being improved.
[0004] The following approaches are learned as the known macromolecule waveguide production approach. namely, the photograph locking which is made to contain a monomer in a macromolecule, is made to react with a monomer by optical exposure, and makes a refractive-index difference with a non-irradiating part or a selection photopolymerization method (Kurokawa et al. --) application (Imamura et al. --) of the approach of using for semi-conductor processings, such as 17 applied optics 646 pages, 1978 and lithography, and etching It is an approach (TOREWERA et al. and 1177 SPIE(s) 397 pages, 1989) using an electronics letter, 27 pages [1342], 1991 and a photosensitive giant molecule, or a resist etc. In these approaches, simplicity is the highest and an approach excellent also in mass-production nature is the approach (approach using a photosensitive giant molecule or a resist) of TOREWERA.
[0005]

[Problem(s) to be Solved by the Invention] However, by the above-mentioned conventional approach, since the ingredient which consists of a macromolecule as a photosensitive ingredient was used, it had the technical problem which should be solved that the pattern dependability especially in a thick film is low, and the technical problem which should be solved that waveguide loss was also high since it is not considered to transparency again. Therefore, the optical components produced using the ingredient concerned have the inadequate field in practicality. Moreover, in order to raise thermal resistance, it also has another technical problem which should be solved that the ingredient containing aromatic series radicals, such as the benzene ring, has a large birefringence. That is, when a giant-molecule thin film is formed using such an ingredient, aromatic series radicals, such as a chain, especially the benzene ring, carry out luminous intensity distribution within a thin film, and optical anisotropy is discovered. For this reason, the optical waveguide produced using the ingredient concerned has the polarization dependency, and since those output characteristics are changed by fluctuation of plane of polarization even if the reinforcement of incident light is fixed, when actually using as waveguide of a single mode system especially, it poses a problem. Since it is necessary to use combining a polarizer etc. and the configuration of an optical device will become quite complicated as a result in order to cancel such a polarization dependency, it is not desirable practically.
[0006] Moreover, when presenting practical use with an optical device, although the economical efficiency becomes important, it is the key factor of cost to connect optical waveguide, and an optical fiber, a light emitting device or a photo detector generally. Because, old connection inserts a lens system between coupling parts in order to adjust the geometry of the greatly different mode field mutually, and it is necessary to carry out jogging alignment of these, and it needs to be fixed so that each optical axis may be in agreement. However, in this case, a lens system is required, assembly operation is complicated and the cost of materials and a conversion cost become expensive. Moreover, although the attempt with the method of doubling was also made in the geometry of the mode field by waveguide processing, even when lateral control was possible, control of the thickness direction was very difficult for it.
[0007] However, it is in offering the macromolecule optical waveguide pattern formation approach for the aperture [which is characterize by using photosensitivity oligomer / which this invention was made in view of such the present condition, the purpose solved the above-mentioned technical problem, and it excelled in thermal resistance and moisture resistance with simple pattern formation ability again, was small, and was excellent in workability /, photographic sensitive film, and liquefied photosensitivity oligomer] conversion to which it is simple, and excels in mass production nature, and connection with optical components is make easily. [of the birefringence]
[0008]
[Means for Solving the Problem] In order to solve the above-mentioned technical problem, the macromolecule optical waveguide pattern formation approach for aperture conversion based on this invention A mask is minded [which should form optical waveguide] to the process which forms the photosensitive matter in the shape of a layer, and the predetermined part of this photosensitive matter. Or it has the process which performs an optical exposure directly and forms a pattern latent image, and the process which removes with a solvent other parts of said photosensitive matter with which said optical exposure was not made. It is the approach of forming the optical waveguide pattern which uses as the core part of optical waveguide said predetermined part in which said pattern latent image was furthermore formed, and said photosensitive matter is characterized by being chosen from the group which consists of photosensitive oligomer and a photographic sensitive film.
[0009] Moreover, the above-mentioned macromolecule optical waveguide pattern formation approach for aperture conversion Furthermore, the process with which said photosensitive matter which formed the liquid pool in the part which should form said optical waveguide beforehand, and became liquefied at this liquid pool is filled, A slot may be formed in the both sides of this liquid pool, an optical fiber may be prepared in this slot, and you may have the process which performs alignment of said photosensitive matter and said optical fiber arranged in said slot, and said core part and said optical fiber make optical connection in this case.

[0010] As another operation gestalt, moreover, the above-mentioned macromolecule optical waveguide pattern formation approach for aperture conversion Furthermore, the process with which said photosensitive matter which formed the liquid pool in the part which should form said optical waveguide beforehand, and became liquefied at this liquid pool is filled, A slot may be formed in the both sides of this liquid pool, a microoptics component may be prepared in this slot, and you may have the process which performs alignment with said microoptics component arranged in said photosensitive matter and said slot, and said core part and said microoptics component make optical connection in this case. Preferably, a microoptics component is chosen from the group which consists of laser diode (LD), light emitting diode (LED), and light-receiving diode (PD).
[0011] Preferably, said photosensitive matter consists of photosensitive oligomer and a photopolymerization initiator.
[0012] Furthermore, said photosensitive oligomer may be either of the following compounds preferably. Namely, a general formula (1)
[0013]
[Formula 12]

(1)

[0014] (Expressing the connection radical which R1 and R2 show a hydrogen atom, a halogen atom, an alkyl group, an alkoxy group, or a trifluoromethyl radical independently among a formula, respectively, and X1, X2, and X3 contain the alkyl group, the alkyl ether radical, and the ring, and contains the OH radical of a piece at least, Y is [0015].)
[Formula 13]


[0016] Or [0017]
[Formula 14]

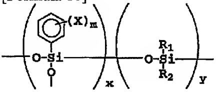

[0018] A ****** active group is shown. Epoxy system oligomer expressed; general formula (2)
[0019]
[Formula 15]

(2)

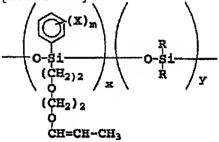
[0020] (X expresses a hydrogen atom, a heavy hydrogen atom, a halogen atom, an alkyl group, and an alkoxy group among a formula, and m expresses the integer of 1-4.) Z is the epoxy group shown in the following type (I) or (II), and [0021].
[Formula 16]

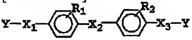
(I)

[0022]
[Formula 17]

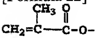
(II)

[0023] x and y -- the abundance of each unit -- being shown -- y -- x -- small -- 0 -- you may be -- it is expressed -- liquefied -- a silicone epoxy oligomer; general formula (3)
[0024]
[Formula 18]

(3)

[0025] (X expresses a hydrogen atom, a heavy hydrogen atom, a halogen atom, an alkyl group, and an alkoxy group among a formula, and m expresses the integer of 1-4.) x and y show the abundance of each unit and x and y are not 0. R1 and R2 a methyl group, an ethyl group, and an isopropyl group -- expressing -- R1 R2 a phase -- being equal -- it is expressed -- liquefied -- silicone oligomer; general formula (4)
[0026]
[Formula 19]

(4)

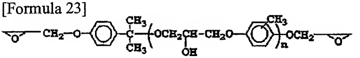
[0027] (X expresses a hydrogen atom, a heavy hydrogen atom, a halogen atom, an alkyl group, and an ARUKOSHIKI radical among a formula, and m expresses the integer of 1-4.) x and y show the abundance of each unit and x and y are not 0. R -- a methyl group, an ethyl group, and an isopropyl group -- expressing -- liquefied silicone vinyl ether oligomer; expressed or a general formula (5)
[0028]
[Formula 20]

(5)

[0029] (R1 and R2 show a hydrogen atom, a halogen atom, an alkyl group, an alkoxy group, or a trifluoromethyl radical independently among a formula, respectively, X1, X2, and X3 contain the alkyl group, the alkyl ether radical, and the ring, they express a connection radical, and Y is [0030].)
[Formula 21]


[0031] Or [0032]
[Formula 22]


[0033] A ****** active group is shown. It is the acrylic oligomer expressed.
[0034] These photosensitive ingredients have simple pattern organization potency, and this invention persons are excellent in thermal resistance and moisture resistance, birefringence is small, they find out that the macromolecule optical waveguide pattern for aperture conversion with which connection with optical components is made easily can be formed, and came to complete this invention.

[0035] That is, in this invention, the waveguide pattern with a steep and smooth wall surface has been formed by hardening the film by optical exposure like the negative resist used by LSI processing etc., and developing negatives with a suitable solvent. It became controllable [the thickness direction] by forming the liquid pool which furthermore controlled an exposure or the depth. Moreover, it made it possible to reduce a birefringence or less to 1x10 to three to having had the big birefringence, in order that a chain may carry out luminous intensity distribution to the conventional macromolecule being very difficult for thick-film formation and waveguide processing, in case the conventional aromatic series content macromolecule optical material forms a thin film possible [waveguide processing] easily with a thick film, and to reduce the polarization dependency of the optical waveguide produced using the ingredient concerned below to an allowed value. This optical material can acquire the suitable viscosity corresponding to formation affirmation of a thin film by adjustment of polymerization degree.
[0036] Hereafter, the contents of this invention are further explained to a detail.
[0037] Macromolecule-ization of the epoxy system oligomer ingredient of this invention is performed by carrying out a polymerization by the reaction by the light between the reaction radicals contained in the component expressed with a general formula. In order to make a reaction fully cause efficiently, it is desirable to add a photopolymerization initiator. Azo compounds, such as peroxides, such as carbonyl compounds, such as a diphenyl triketone benzoin, benzoin methyl ether, a benzophenone, an acetophenone, and diacetyl, and a benzoyl peroxide, and azobisisobutyronitril, are mentioned as a typical thing that what is necessary is just what is generally used as a photopolymerization initiator as a photopolymerization initiator.
[0038] Moreover, macromolecule-ization of the silicone system oligomer ingredient of this invention is based on the reaction of a sensitization agent and oligomer. As a sensitization agent, bis-azide compounds, such as azide compound [, such as an azide pyrene], 4, and 4'-diazido benzalacetone, 2, 6-G (4'-azide benzal) cyclo hexano, 2, and 6-G (4'-azide benzal)-4-methylcyclohexanone, and a diazo compound are typical.
[0039] When producing optical waveguide using the above mentioned photographic sensitive film and the above mentioned photosensitive oligomer ingredient according to this invention, the process can be performed as follows. That is, a waveguide pattern is formed by putting a photographic sensitive film and oligomer into spreading or a liquid reservoir, carrying out alignment on a substrate or a clad, and carrying out dissolution removal of direct Mitsuteru putting and the part which is not irradiated with a solvent through a mask. In this way, since the produced optical waveguide has the small birefringence of the ingredient excelled and used for solvent resistance, its polarization dependency is small, and it is low guided wave loss, and is excellent in thermal resistance and moisture resistance.
[0040]
[Embodiment of the Invention] The example of the macromolecule optical waveguide pattern formation approach for aperture conversion based on this invention is explained to a detail below. Of course, this invention is not limited to the example of these operation gestalt, and it can understand it easily for a various modification and other various examples of an operation gestalt to be possible the thought of this invention and within the limits of it, if it is this contractor.
[0041] It is the following, and the macromolecule optical waveguide pattern for <example 1> aperture conversion was made and formed.
[0042] The solution 10 which adjusted the liquefied epoxy oligomer which has first the structure expression (6) shown below, and 2 % of the weight of photopolymerization initiators was prepared.
[0043]
[Formula 23]



(6)

[0044] (The inside n of a formula is 1, 2, or 3)
Next, as shown in drawing 1 (a), with a thickness of 100 micrometers epoxy resin 12a which has the

liquid reservoir 11 with a depth [of 63 micrometers] x width-of-face [of 50mm] x die length of 50mm prepared the platform 12 formed on substrate 12b. The refractive index of this epoxy resin 12a was 1.52 on the wavelength of 0.85 micrometers. It continued and the above-mentioned solution 10 was poured into the liquid reservoir 11 of a platform 12.

[0045] As shown in drawing 1 (b) after impregnation of a solution 10, ultraviolet rays (UV light) 14 were irradiated on the platform 12 through the mask 13 which has two or more optical waveguide pattern 13a which consists of a pattern corresponding to a ridge (drawing 1 (c)). Under the present circumstances, the end section to which the width of face of each optical waveguide pattern 13a formed in the mask 13 met the longitudinal direction is 52 micrometers, and the other end has become 60 micrometers. Therefore, the width of face of each optical waveguide pattern 13a is changing continuously along with a longitudinal direction. 1700 mJ/cm [as opposed to / according to change of the width of face of each optical waveguide pattern 13a / the above-mentioned end section in the exposure of the above-mentioned UV light 14]2 from -- 2000 mJ/cm2 to the above-mentioned other end up to -- it was made to change continuously

[0046] The sample was developed after the exposure of UV light using the isopropanol solution. Consequently, according to optical waveguide pattern 13a of a mask 13, liquefied epoxy oligomer hardened only the optical exposure section, and the ridge pattern 15 of a configuration as shown in drawing 1 (d) has been produced. The refractive index after hardening was 1.535 on the wavelength of 0.85 micrometers. Then, the epoxy resin adjusted so that the refractive index at the time of photo-curing might be set to 1.52 on the wavelength of 0.85 micrometers on this ridge pattern 15 is applied further, and was stiffened, and optical waveguide was produced.

[0047] The multimode channel optical waveguide 18 which has the core 17 from which the width of face of the core of the refractive index of the clads 16 and 1.535 which consist of an epoxy resin of a refractive index 1.52 changed with such actuation continuously from 52 micrometers to 60 micrometers along with the longitudinal direction was obtained (refer to drawing 1 (e) and (f)).

[0048] When this multimode channel optical waveguide 18 was started so that it might become the die length whose one side is 5cm with a dicing saw, and the insertion loss was further measured using GI fiber of 50 micrometers of diameters, and 62.5 micrometers of diameters, it was 3.0dB or less on 1.5dB or less and the wavelength of 1.55 micrometers in 1dB or less and 1.3 micrometers with the wavelength of 0.85 micrometers. Joint loss with the fiber at that time was 0.1dB or less. Moreover, as for the polarization dependency of an insertion loss, the wavelength of 1.3 micrometers or the wavelength of 1.55 micrometers was 0.1dB or less. Furthermore, loss of this optical waveguide was not changed one month or more under the condition of 75 degrees C / 90%RH.

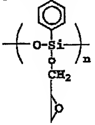
[0049] <Example 2> drawing 2 is for explaining each process of the formation approach of the optical waveguide pattern by this example.

[0050] First, as shown in drawing 2 (a), platform 22a which consists of epoxy resin 22a by which thickness is 100 micrometers and the liquid reservoir 21 was formed on substrate 22b was prepared. The refractive index of this epoxy resin was 1.52 on the wavelength of 0.85 micrometers. Moreover, the dimension of a liquid reservoir 21 shall be 50mm in width-of-face [of 50mm] x die length, and the depth shall change from an end continuously towards the other end (that is, an end side is set to 52 micrometers and an other end side is set to 60 micrometers). Moreover, slot 22c of the shape of the shape of V character and a rectangle is formed along the direction in which the inclination of this depth is formed on platform 22a located in the both sides of the above-mentioned liquid reservoir 21, and the GI optical fiber (62.5 micrometers of diameters) 23 and the GI optical fiber (50 micrometers of diameters) 24 are arranged to this slot 22c, respectively. An optical fiber 23 and an optical fiber 24 counter mutually on both sides of a liquid reservoir 21.

[0051] Next, the solution 10 of the same presentation as what was prepared in the example 1 was poured into the liquid reservoir 11 (refer to drawing 2 (a)).

[0052] As shown in drawing 2 (b) after impregnation of a solution 10, ultraviolet rays (UV light) 26 were irradiated on the platform 22 through the mask 25 which has two or more optical waveguide pattern 25a which consists of a pattern corresponding to a ridge (drawing 2 (c)). Under the present

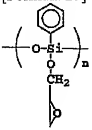
circumstances, the end section to which the width of face of each optical waveguide pattern 25a formed in the mask 25 met the longitudinal direction is 52 micrometers, and the other end has become 60 micrometers. Therefore, the width of face of each optical waveguide pattern 25a is changing continuously along with a longitudinal direction with change of the depth. The exposure of the above-mentioned UV light 26 is 2000 mJ/cm2 to homogeneity to optical waveguide pattern 25a. It carried out.
[0053] The sample was developed after the exposure of UV light using the isopropanol solution. Consequently, according to optical waveguide pattern 25a of a mask 25, liquefied epoxy oligomer hardened only the optical exposure section, and the ridge pattern 27 of a configuration as shown in drawing 2 (d) has been produced. The refractive index after hardening was 1.535 on the wavelength of 0.85 micrometers. Then, the epoxy resin adjusted so that the refractive index at the time of photo-curing might be set to 1.52 to this ridge pattern on the wavelength of 0.85 micrometers is applied further, and was stiffened, and optical waveguide was produced (refer to drawing 2 (e)).
[0054] The multimode channel optical waveguide 29 which has the core 27 from which the core diameter of the refractive index of the clads 28 and 1.535 which consist of an epoxy resin of a refractive index 1.52 changed with such actuation continuously from 52 micrometers to 60 micrometers along with the longitudinal direction was obtained.
[0055] When this multimode channel optical waveguide was started so that it might become the die length whose one side is 5cm with a dicing saw, and the insertion loss was further measured using GI fiber of 50 micrometers of diameters, and 62.5 micrometers of diameters, it was 3.0dB or less on 1.5dB or less and the wavelength of 1.55 micrometers in 1dB or less and 1.3 micrometers with the wavelength of 0.85 micrometers. Joint loss with the optical fiber at that time was 0.1dB or less. Moreover, as for the polarization dependency of an insertion loss, the wavelength of 1.3 micrometers or the wavelength of 1.55 micrometers was 0.1dB or less. Furthermore, loss of this optical waveguide was not changed one month or more under the condition of 75 degrees C / 90%RH.
[0056] Except having changed the presentation of the resin used for forming <example 3> optical waveguide, the optical waveguide pattern was formed as it is also with the same approach as an example 2.
[0057] In this example, the channel waveguide for multimodes was produced using the solution which adjusted the liquefied silicone epoxy oligomer and the amount of photopolymerization initiator duplexs which are expressed with the following structure expressions (7).
[0058]
[Formula 24]



(7)

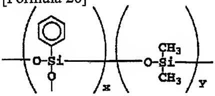
[0059] When this optical waveguide was started in die length of 5cm with the dicing saw and the insertion loss was measured using GI fiber of 50 micrometers of diameters, and 62.5 micrometers of diameters, it was 1.5dB or less on 1.0dB or less and the wavelength of 1.55 micrometers in 1.3 micrometers. Moreover, as for the polarization dependency of an insertion loss, the wavelength of 1.3 micrometers or the wavelength of 1.55 micrometers was 0.1dB or less. Joint loss with the fiber at that time was 0.1dB or less. Furthermore, loss of this optical waveguide was not changed one month or more under the condition of 75 degrees C / 90%RH.
[0060] Except having changed the presentation of the resin used for forming <example 4> optical waveguide, the optical waveguide pattern was formed as it is also with the same approach as an example 2.
[0061] In this example, the channel waveguide for multimodes was produced using the solution which

adjusted the liquefied silicone epoxy oligomer and the amount of photopolymerization initiator duplexs which are expressed with the following structure expressions (8).
[0062]
[Formula 25]



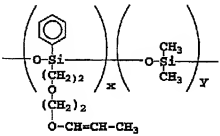
(8)

[0063] When this optical waveguide was started in die length of 5cm with the dicing saw and the insertion loss was measured using GI fiber of 50 micrometers of diameters, and 62.5 micrometers of diameters, it was 1.5dB or less on 1.0dB or less and the wavelength of 1.55 micrometers in 1.3 micrometers. Moreover, as for the polarization dependency of an insertion loss, the wavelength of 1.3 micrometers or the wavelength of 1.55 micrometers was 0.1dB or less. Joint loss with the fiber at that time was 0.1dB or less. Furthermore, loss of this optical waveguide was not changed one month or more under the condition of 75 degrees C / 90%RH.
[0064] Except having changed the presentation of the resin used for forming <example 5> optical waveguide, the optical waveguide pattern was formed as it is also with the same approach as an example 2.
[0065] The channel waveguide for multimodes was produced using the solution which adjusted the liquefied silicone oligomer and the amount of photopolymerization initiator duplexs which are expressed with the following structure expression (9).
[0066]
[Formula 26]



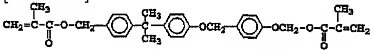
(9)

[0067] (X:Yin formula = 7:5)
When this optical waveguide was started in die length of 5cm with the dicing saw and the insertion loss was measured using GI fiber of 50 micrometers of diameters, and 62.5 micrometers of diameters, it was 1.5dB or less on 0.1dB or less and the wavelength of 1.55 micrometers in 1.3 micrometers. Moreover, as for the polarization dependency of an insertion loss, the wavelength of 1.3 micrometers or the wavelength of 1.55 micrometers was 0.1dB or less. Joint loss with the fiber at that time was 0.1dB or less. Furthermore, loss of this optical waveguide was not changed one month or more under the condition of 75 degrees C / 90%RH.
[0068] Except having changed the presentation of the resin used for forming <example 6> optical waveguide, the optical waveguide pattern was formed as it is also with the same approach as an example 2.
[0069] That is, the solution which adjusted the liquefied silicone vinyl ether oligomer and the amount of photopolymerization initiator duplexs which are expressed with the following structure expression (10) was used.
[0070]
[Formula 27]



(10)

[0071] When the obtained optical waveguide was started in die length of 5cm with the dicing saw and the insertion loss was measured using GI fiber of 50 micrometers of diameters, and 62.5 micrometers of diameters, it was 1.5dB or less on 1.0dB or less and the wavelength of 1.55 micrometers in 1.3 micrometers. Moreover, as for the polarization dependency of an insertion loss, the wavelength of 1.3 micrometers or the wavelength of 1.55 micrometers was 0.1dB or less. Joint loss with the fiber at that time was 0.1dB or less. Furthermore, loss of this optical waveguide was not changed one month or more under the condition of 75 degrees C / 90%RH.
[0072] Except having changed the presentation of the resin used for forming <example 7> optical waveguide, the optical waveguide pattern was formed as it is also with the same approach as an example 2.
[0073] In this example, the solution which adjusted the liquefied acrylic oligomer and the amount of photopolymerization initiator duplexs which have the structure expression (11) shown below was prepared.
[0074]
[Formula 28]

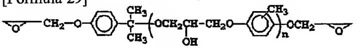


(11)

[0075] When the produced optical waveguide for multimodes was started in die length of 5cm with the dicing saw and the insertion loss was measured using GI fiber of 50 micrometers of diameters, and 62.5 micrometers of diameters, it was 1.5dB or less on 1.0dB or less and the wavelength of 1.55 micrometers in 1.3 micrometers. Moreover, as for the polarization dependency of an insertion loss, the wavelength of 1.3 micrometers or the wavelength of 1.55 micrometers was 0.1dB or less. Joint loss with the fiber at that time is 0.1dB or less, and is ****. Furthermore, loss of this optical waveguide was not changed one month or more under the condition of 75 degrees C / 90%RH.
[0076] INTAKONEKUTO [in accordance with the process shown in drawing 2 , multichannel optical waveguide was produced using the solution prepared from the liquefied silicone epoxy oligomer used in the <example 8> example 2, and 2 % of the weight of photopolymerization initiators, and / the transceiver device].
[0077] First, as shown in drawing 2 (a), the platform 22 which consists of epoxy resin 22a by which thickness is 100 micrometers and the liquid reservoir 21 was formed on substrate 22b was formed. The refractive index of this epoxy resin was 1.52 on the wavelength of 0.85 micrometers. Moreover, the dimension of a liquid reservoir 21 shall be 50mm in width-of-face [of 50mm] x die length, and the depth shall change from an end continuously towards the other end (that is, an end side is set to 48 micrometers and an other end side is set to 4 micrometers). Moreover, slot 22c of the shape of the shape of V character and a rectangle is formed along the direction in which the inclination of this depth is formed on platform 22a located in the both sides of the above-mentioned liquid reservoir 21, and to this slot 22c, on both sides of a liquid reservoir 21, a laser light source (oscillation wavelength of 0.85 micrometers) 23 and an electric eye 24 are arranged, as it counters mutually. Here, 2x5 micrometers and the light-receiving side of an electric eye 24 of the luminescence area of a laser light source 23 are the diameters of 50 micrometer.
[0078] Next, the solution 10 of the same presentation as what was prepared in the example 1 was poured

into the liquid reservoir 11 (refer to drawing 2 (a)).
[0079] As shown in drawing 2 (b) after impregnation of a solution 10, ultraviolet rays (UV light) 26 were irradiated on the platform 22 through the mask 25 which has two or more optical waveguide pattern 25a which consists of a pattern corresponding to a ridge (drawing 2 (c)). Under the present circumstances, the end section to which the width of face of each optical waveguide pattern 25a formed in the mask 25 met the longitudinal direction is 48 micrometers, and the other end has become 4 micrometers. Therefore, the width of face of each optical waveguide pattern 25a is changing continuously along with a longitudinal direction with change of the depth. The exposure of the above-mentioned UV light 26 is 2000 mJ/cm2 to homogeneity to optical waveguide pattern 25a. It carried out.
[0080] The sample was developed after the exposure of UV light using the isopropanol solution. Consequently, according to optical waveguide pattern 25a of a mask 25, liquefied epoxy oligomer hardened only the optical exposure section, and the ridge pattern 27 of a configuration as shown in drawing 2 (d) has been produced. The refractive index after hardening was 1.52 on the wavelength of 0.85 micrometers. Then, the epoxy resin adjusted so that the refractive index at the time of photo-curing might be set to 1.52 to this ridge pattern on the wavelength of 0.85 micrometers is applied further, and was stiffened, and the multimode channel optical waveguide 29 was produced (refer to drawing 2 (e)).
[0081] The optical waveguide device 200 in which the core diameter of the refractive index of the clads 28 and 1.535 which consist of an epoxy resin of a refractive index 1.52 has the multimode channel optical waveguide 29 which has the core 27 which changed continuously from 48 micrometers to 2 micrometers along with the longitudinal direction by such actuation was obtained (refer to drawing 2 (f)).
[0082] When the optical transceiver device and light was introduced, joint loss of a transmitting side was [0.3dB and joint loss of a receiving side] about 0.1dB. [this multimode channel optical waveguide device 200]
[0083] INTAKONEKUTO [in accordance with the process shown in drawing 2 , multichannel optical waveguide was produced like the example 8, and / the transceiver device] except having used the solution prepared from the liquefied silicone epoxy oligomer used in the <example 9> example 3, and 2 % of the weight of photopolymerization initiators.
[0084] Thus, the waveguide component [INTAKONEKUTO / using the obtained multichannel optical waveguide / component / the optical transceiver device] 200 was producible (drawing 2 (e)). When light was introduced into this optical waveguide from 22, 0.3dB of joint loss and the joint loss by the side of light-receiving were about 0.1dB.
[0085] INTAKONEKUTO [in accordance with the process shown in drawing 2 , multichannel optical waveguide was produced like the example 8, and / the transceiver device] except having used the solution prepared from the liquefied silicone epoxy oligomer used in the <example 10> example 4, and 2 % of the weight of photopolymerization initiators.
[0086] Thus, the optical waveguide device [INTAKONEKUTO / using the obtained multichannel optical waveguide / optical waveguide device / the optical transceiver device] 200 was producible (drawing 2 (f)). When light was introduced into this optical waveguide from 22, 0.3dB of joint loss and the joint loss by the side of light-receiving were about 0.1dB.
[0087] INTAKONEKUTO [in accordance with the process shown in drawing 2 , multichannel optical waveguide was produced like the example 8, and / the transceiver device] except having used the solution prepared from the liquefied silicone epoxy oligomer used in the <example 11> example 5, and 2 % of the weight of photopolymerization initiators.
[0088] Thus, the optical waveguide device [INTAKONEKUTO / using the obtained multichannel optical waveguide / optical waveguide device / the optical transceiver device] 200 was producible (drawing 2 (f)). When light was introduced into this optical waveguide from 22, 0.3dB of joint loss and the joint loss by the side of light-receiving were about 0.1dB.
[0089] INTAKONEKUTO [in accordance with the process shown in drawing 2 , multichannel optical waveguide was produced like the example 8, and / the transceiver device] except having used the solution prepared from the liquefied silicone epoxy oligomer used in the <example 12> example 6, and

2 % of the weight of photopolymerization initiators.
[0090] Thus, the optical waveguide device [INTAKONEKUTO / using the obtained multichannel optical waveguide / optical waveguide device / the optical transceiver device] 200 was producible (drawing 2 (f)). When light was introduced into this optical waveguide from 22, 0.3dB of joint loss and the joint loss by the side of light-receiving were about 0.1dB.
[0091] It is the following, and the macromolecule optical waveguide pattern for <example 13> aperture conversion was made and formed.
[0092] The solution 30 which first adjusted the liquefied epoxy oligomer which has the same structure expression (6) as an example 1, and 2 % of the weight of photopolymerization initiators was prepared.
[0093]
[Formula 29]



(6)

[0094] Next, as shown in drawing 3 (a), with a thickness of 500 micrometers epoxy resin 32a which has the liquid reservoir 31 with a depth [of 200 micrometers]-300micrometerx width-of-face [of 50mm] x die length of 50mm prepared the platform 32 formed on substrate 32b. Moreover, along the direction in which the inclination of the depth is formed, slot 22c of the shape of the shape of V character and a rectangle is formed in the both sides of a liquid reservoir 31, and the polymer clad fiber 39 and LED301 are arranged to this slot 32c, respectively. The refractive index of this epoxy resin 12a was 1.52 on the wavelength of 0.85 micrometers. It continued and the above-mentioned solution 30 was poured into the liquid reservoir 31 of a platform 32.
[0095] As shown in drawing 3 (b) after impregnation of a solution 10, ultraviolet rays (UV light) 34 were irradiated on the platform 32 through the mask 33 which has two or more optical waveguide pattern 33a which consists of a pattern corresponding to a ridge (drawing 3 (c)). Under the present circumstances, the end section to which the width of face of each optical waveguide pattern 33a formed in the mask 33 met the longitudinal direction is 200 micrometers, and the other end has become 300 micrometers. Therefore, the width of face of each optical waveguide pattern 33a is changing continuously along with a longitudinal direction. 1700 mJ/cm [as opposed to / according to change of the width of face of each optical waveguide pattern 33a / the above-mentioned end section in the exposure of the above-mentioned UV light 34]2 from -- 2000 mJ/cm2 to the above-mentioned other end up to -- it was made to change continuously
[0096] The sample was developed after the exposure of UV light using the isopropanol solution. Consequently, according to optical waveguide pattern 33a of a mask 33, liquefied epoxy oligomer hardened only the optical exposure section, and the ridge pattern 35 of a configuration as shown in drawing 3 (d) has been produced. The refractive index after hardening was 1.54 on the wavelength of 0.85 micrometers. Then, the epoxy resin adjusted so that the refractive index at the time of photo-curing might be set to 1.51 to this ridge pattern on the wavelength of 0.85 micrometers is applied further, and was stiffened, and optical waveguide was produced.
[0097] The multimode channel optical waveguide 38 which has the core 37 from which the width of face of the core of the refractive index of the clads 36 and 1.54 which consist of an epoxy resin of a refractive index 1.51 changed with such actuation continuously from 200 micrometers to 300 micrometers along with the longitudinal direction was obtained (refer to drawing 3 (e)).
[0098] This multimode channel optical waveguide 38 was started so that it might become the die length whose one side is 5cm with a dicing saw, it was 200 micrometers in bore further, and when the insertion loss was measured using the polymer GURADDO fiber 39 with an outer diameter of 230 micrometers, it was 3.0dB or less on 1dB or less and the wavelength of 1.3 micrometers in 1dB or less and 0.633 micrometers with the wavelength of 0.85 micrometers. Joint loss with the fiber at that time was 0.1dB or less. Moreover, as for the polarization dependency of an insertion loss, the wavelength of 1.3 micrometers or the wavelength of 1.55 micrometers was 0.1dB or less. Furthermore, loss of this optical

waveguide was not changed one month or more under the condition of 75 degrees C / 90%RH. Furthermore, as shown in drawing 3 (f), the core diameter side of 300 micrometers shown by the reference mark 300 of this multimode channel optical waveguide 38 was equipped with LED (a luminescence area of 250 micrometers, oscillation wavelength of 0.66 micrometers)301, and optical coupling was performed. Consequently, joint loss of LED and optical waveguide was about 1dB in good value.

[0099] According to the macromolecule optical waveguide pattern formation approach for aperture conversion based on the above examples 1-13, it makes it possible for the above-mentioned photosensitive ingredient used for these examples 1-13 to have simple pattern formation ability, and to excel in thermal resistance and moisture resistance, and to make connection with optical components easily, since the birefringence is small.

[0100]

[Effect of the Invention] As explained above, according to the macromolecule optical waveguide pattern formation approach for aperture conversion based on this invention, it becomes easy mass production and to carry out a low low price about the macromolecule optical waveguide components for aperture conversion which make connection between components simple in optical communication and an optical-information-processing system. Furthermore, if this invention is used, since the aperture conversion of a light beam which becomes important in the case of connection will become realizable, it becomes possible to include an aperture conversion function in various optical waveguides, optical integrateds circuit, or optical patchboards etc. which are used in general optics, the microoptics field, and the field of optical communication or optical information processing easily.

[Translation done.]